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Four-Stage Framework for Implementing a Chatbot System in Disaster Emergency Operation Data Management: A Flood Disaster Management Case Study

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ABSTRACT

This research proposes a four-stage consultant framework for applying a chatbot as a data management system. With the advancement of computational power and data storage technology, the increasing amount of data makes the issue of data management difficult to address. Management of a massive amount of data by utilizing chatbots to play the roles of a data manager and a data provider has been extensively studied. Although a chatbot system has been proven to increase the overall efficiency of data management, implementing a chatbot system in a government department remains a challenge, especially in a field with highly complex data. This research presents the authors' experience of applying a chatbot system in a department of the government of Taiwan for disaster response operations. A four-stage consulting framework comprising 1) existing workflow review, 2) usability evaluation, 3) system improvement, and 4) management plan (EUSM) was thus proposed. After a two-year field test, the authors found that the framework could help the department in clarifying their working process, increase the overall efficiency of the chatbot system, and identify the major issues of introducing the chatbot system.

1. Introduction

In the field of disaster management, having a well-designed system to manage the huge amounts and large varieties of data is considered a critical issue. During the disaster response period, it is important to implement a system that can handle the related data accurately, timely, and effectively (Careem et al., 2006). The decision makers of the government can use the related data for prevention, early alarming, disaster detection, and even decision support (Köhler and Wa, 2006; Tsai et al., 2013; Marzoughia et al., 2018). With the development of technologies, an increasing amount of disaster-related data is produced every day (Grolinger et al., 2013). The increase in the amount of data leads to difficulties for the user in managing and utilizing the data appropriately.

The importance of disaster-related data has been studied extensively (Hristidis et al., 2010). The use of information technology (IT) in addressing the enormous amount of disaster-related data has also been widely investigated (Meissner et al., 2002). Traditional IT systems, such as database and data integration systems, have been developed and utilized in the process of disaster-related decision making in government departments. Recently, with the growth of the usage and computational power of mobile devices, new types of IT services, such as social media-based data collection applications, applications for data operation and management, or a messenger-based chatbot system, have been introduced in the field of disaster management.

Among the new types of IT services, the messenger-based chatbot system has now become a promising direction in the application of data management owing to the popularity of online messenger and its low learning threshold. Although several new systems have been developed for the field of disaster response and management, it may still be difficult for the related department, especially within the government, to introduce a new system into their existing processes. Most government

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departments have their own but usually old systems for disaster response. Adopting new technology may have significant influences on different personnel or even decision-making processes; for this reason, governments are hesitant about the use of new technologies. Therefore, this research aims to develop a consultant framework to help government departments implement a new messenger-based chatbot system to improve their current processes. The developed consultant framework will be implemented in Taiwan's government to confirm that it can help the government institution to utilize such new technologies. Also, the usability of a chatbot system will be tested through a usability test and user interview.

2. Related Works

2.1 Information Technology in Disaster Data Management

With the rapid growth of sensing technologies, the amount of disaster-related data that can be acquired these days has compounded. For instance, satellite remote sensing technology can provide high-coverage and -resolution images for post-disaster damage assessment and mitigation of disasters (Yamazaki and Matsuoka, 2007; Skakun et al., 2014). To deal with the huge amount of data, studies have been conducted to implement IT to help the related personnel process the raw data and convert them into useful information. The IT services have been utilized in five major areas: the data supplier system, data distribution system (DDS), data management system (DMS) (Pradhan et al., 2007), data processing and application development (DPAP), and decision support system (DSS) (Assilzadeha and Mansora, 2004).

Database is one of the most common IT services utilized in the field of disaster management. A database that gathers disaster-related data can play the role of data supplier for disaster prevention, response, and reduction (Kang et al., 2012). Systems based on the Internet of Things (IoT) have been developed to manage and process the disaster-related data obtained from the database and convert them into useful information. For instance, Tsai et al. (2019a) developed T-search, which allows the user to obtain historical typhoon information through a web interface (Tsai et al., 2019a). Chen et al. (2011) proposed a system with integration of Geographic Information System (GIS) to support the equipment distributions during the disaster response period (Chen et al., 2011). Hannan et al. (2018) proposed a Named Data Network-Based IoT-DMS system for sending push notifications of emergency contents to customers (Hannan et al., 2018). In addition, as the usage of mobile devices and social media grows, studies have been conducted to collect disaster data through crowdsourcing or crawlers on social media. Lin et al. (2018) used crowdsourcing to help the government filter disaster responses. They gathered 284 volunteers from the internet to eliminate useless or repeated information (Lin et al., 2018). Middleton et al. (2014) used social media to develop a crisis mapping platform for natural disasters (Middleton et al., 2014). iRescue, which was developed by Yoon et al. (2015), was a system built on mobile devices for locating and assessing the disaster victim (Yoon et al., 2015). Radmehr and Araghinejad (2014) developed a spatial multicriteria decision making with artificial neural network technology for urban region's flood management (Radmehr and Araghinejad, 2014).

Nowadays, the age of big data has led the disaster management to a new era (Yu et al., 2018). How to utilize new technologies and implement them in the current process for predicting, analyzing, and reducing natural disasters has become an urgent research area.

2.2 Background of Chatbot Systems

Among those newly developed IT services, the chatbot system with artificial intelligence has gained the attention of many researchers and organizations in different fields. A chatbot system built into a machine can process nonstructural data and allow the machine to interact with humans and even help them acquire the data that they need through conversation (Yan et al., 2016; Chung et al., 2017). Due to its user-friendly interface and low learning threshold, the chatbot system has currently been utilized in many fields. For example, in the field of business, chatbot systems have been developed as the virtual assistant (Ko and Lin, 2018) and provider of customer service for e-business (Gupta et al., 2015; Thomas, 2016; Cui et al., 2017). In addition to business-related applications, chatbot systems are widely utilized in healthcare services (Comendador et al., 2015; Fadhil and Gabrielli, 2017; Oh et al., 2017; Chung and Park, 2019).

According to the report from Business Insider Intelligence, the usage of messaging apps has surpassed that of social network apps since the end of 2014 (Business Insider Intelligence, 2016). As part of the decision support team of the Water Resource Agency (WRA) of the Taiwanese government, the authors also found that decision makers currently rely on messaging apps to communicate with each other for developing disaster prevention strategies. Our research team developed a messaging app-based chatbot system for disaster management in 2018 (Tsai et al., 2019b). The chatbot system, named Ask Diana, gathers most of the water-related disaster data and allows the decision makers to acquire data through conversation on a commercial messaging app, Line. We also developed a dialogue system for decision makers at an emergency operation center to assist them in the utilization, selection, and processing of information efficiently and accurately (Chan and Tsai, 2019; Kung et al., 2020).

2.3 Requirements of a Consulting Framework

Although the authors already developed a chatbot to be used as a disaster data management system by decision makers in the government, the authors realized that it was difficult for the government to implement the system within their current processes. The decision makers may somehow resist the use of a new technology or system because every change in the decision-making processes may have significant effects on the residents. A consulting framework is thus needed for helping the agency to implement a new technology (Tsai et al., 2010).

The consulting framework should help the development team identify actual user needs so that the system can hit the pain point and increase the users' willingness to implement the system. In addition, the framework should contain system developing processes, including prototyping, testing, improving, and long-term planning (Tsai et al., 2014). Lastly, the framework needs to be validated using a successful implementation case.

3. Research Objectives

This research aims to develop a consulting framework to help a government department utilize a chatbot as the data management system for disaster response. Although many chatbot systems have been developed for data management, the challenge of how to assist the relevant department in incorporating such new technologies into their existing processes, especially in the field of disaster prevention, is seldom discussed. Therefore, this research proposes a consulting framework that contains every system implementation stage, including user need definition, system design, usability tests, and system management plan. The framework should be validated through a successful implementation in a real context.

4. EUSM Framework

This research proposes a consulting framework, coined as EUSM (existing workflow review, usability evaluation, system improvement, and management plan), which is a four-stage framework for introducing a chatbot system as a data management tool for the department of disaster response operations (Fig. 1). The four stages are existing workflow review, usability evaluation, system improvement, and management plan.

4.1 Existing Workflow Review

In the existing workflow review stage, the current state of the entire workflow, including data processing, storing, retrieving, and managing, is reviewed. The development team should go through the current workflow of the disaster response mechanism. A workflow chart should be used in this stage to gain a better understanding of the decision-making processes. After reviewing the current state, the potential roles that a chatbot system plays can thus be identified.

Further, a face-to-face interview with the future users should be conducted to assess their real needs, including the type of data or information that the user needs, how the user would like to classify the data, and the kind of data acquisition or data-revealing approach that the user prefers. In terms of the subjects of the interview, the real decision makers should be involved at this stage to ensure that the newly developed system can fit their needs and thus persuade them to use the system in the future.

4.2 Usability Evaluation

The second stage is usability evaluation. At this stage, the system is prototyped on the basis of the results of the first stage. The prototype does not need to be a well-designed system. However, it should be able to operate in a real device so that the user behavior and feedback can be collected through both in-lab and on-field tests.

As for the test, the scenario-based usability test is recommended at this stage. The development team can use the developed prototype with different scenarios to test how the user will use the system. The team can follow the current decision-making process acquired in the previous stage to design different scenarios for the test. For instance, if an earthquake occurs and 15 minutes have passed, what kinds of decisions should the disaster response personnel make? During the test, the feedback can be collected by observing the user behavior when operating the system. Further, when selecting the subjects of the in-field test, the team should ensure that the selected users should include not only the actual users of the system in the future but also the decision makers of the disaster response process.

4.3 System Improvement

The third stage is the system improvement. At this stage, the feedback gathered from the actual users should be reviewed and analyzed to determine the types of improvement that should be performed. Lastly, the system should be improved according to the review results to achieve better use.

To improve the data management system for decision support, any feedback should be reviewed according to four major perspectives: data completeness, data revealing approach, operation process, and decision support information. In terms of data completeness, the team needs to assess if the system covers enough data for users' daily tasks. Since a chatbot system is

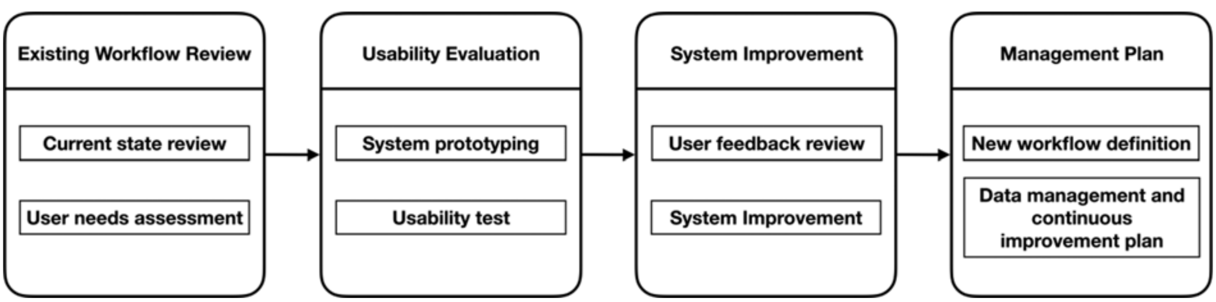


Fig. 1. EUSM Consulting Framework

usually built on a mobile device, the data revealing method should also be appropriate to facilitate better and faster understanding. Further, the system operation process should also be checked to see if it is sufficiently intuitive for the user. Lastly, whether the information in the system is sufficient for helping the decision-making process should be confirmed.

4.4 Management Plan

The last stage is the management plan. At this stage, a new workflow incorporating the implementation of the chatbot system should be developed. The development team should modify or even develop a new workflow by involving the newly developed chatbot system. Such a workflow can help the user to understand the kinds of roles that the chatbot system can play in the disaster response process.

With the newly developed workflow, the system should be implemented in the user's daily tasks with the assistance of the development team. The data management standard, such as the data exchange rules and the data updating frequency, should be planned at this stage. After a long-term implementation of the system, the team should conduct user interviews regularly to improve the system continuously by making it more reliable and useful in the actual field.

5. Implementation and Case Study

In terms of implementation and case study, this research investigates the Water Hazard Mitigation Center, a disaster response department of the government of Taiwan, by implementing the framework for a practical plan of introducing the chatbot system in the data management process. The authors of this research have played the role of the data processor, provider, and manager in the government department for more than ten years. Recently, the authors developed a chatbot system, named Ask Diana, to improve the existing data management process.

Ask Diana is a conversation-based system for managing disaster-related data. It is built on Line, one of the most popular communication platforms in Taiwan. A two-year real field test conducted on Ask Diana proved the system's positive impact on managing highly complex disaster-related data for emergency response operations. When implementing Ask Diana for the government department, the EUSM framework was utilized for system development, possible problem identification, and long-term management plan. The following sections will provide stage-by-

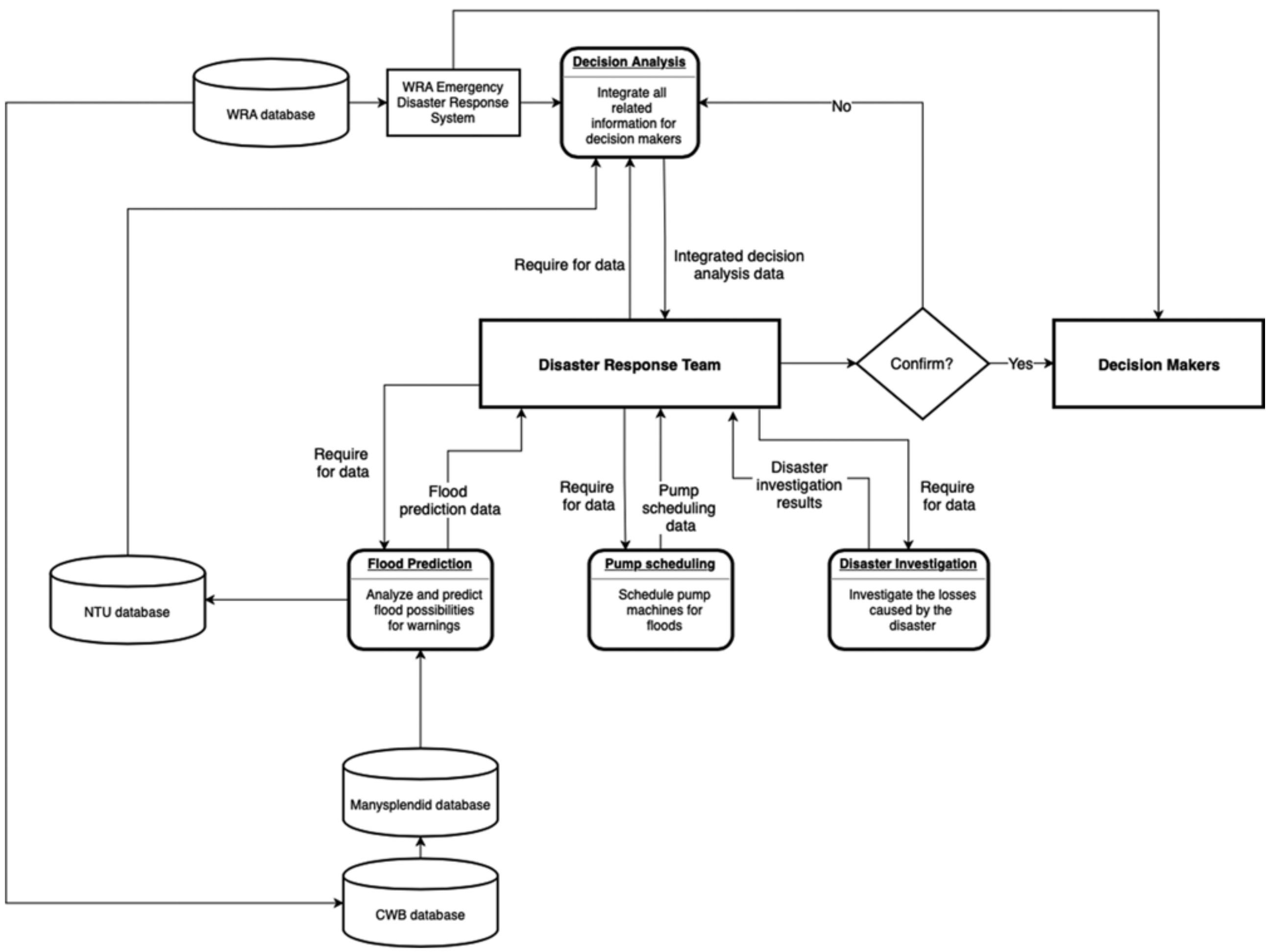


Fig. 2. Current Workflow of Decision Making in the WRA

stage illustration of how the EUSM was conducted in a real case.

5.1 Stage 1: Existing Workflow Review

5.1.1 Current Workflow Review

In this research, the authors have played the role of the decision support team in the WRA for more than ten years. The current workflow review was thus conducted on the basis of the personal experience of the authors. Fig. 2 illustrates the current workflow of decision making in the WRA. In the current workflow, four main processes need to be conducted for decision support: decision analysis, flood prediction, pump scheduling, and disaster investigation.

For the disaster investigation process, the National Cheng Kung University (NCKU) team investigates the losses caused by the disaster and provides the results to the disaster response team. For the pump scheduling process, the internal team of the WRA is in charge of arranging the pump machine to places affected by floods. The National Taiwan University (NTU) team conducts both the flood prediction process and decision analysis process. In the flood prediction process, the NTU team uses the data from Manysplendid Infotech, Ltd., a company that processes the weather observation data for flood prediction, to predict the possible flooding areas in Taiwan. In the decision analysis process, the NTU team integrates all the related information, such as river water levels and reservoir data, by using the WRA Emergency Disaster Response System.

5.1.2 User Need Assessment

Five decision makers of the WRA in Taiwan were interviewed to determine the types of data that they would need during the disaster response period for decision support. Based on the interview, the required data can be categorized into five major types: the weather observation data, statistical preparation data, disaster prevention operation data, historical experience data, and international disaster data. Table 1 illustrates the results of the interview. The detailed interview descriptions can be found in our previously published paper (Tsai et al., 2019b).

Based on the results of the interview, the authors found that some of the data were real-time observational data and were provided as well as processed by other agencies, which may need several APIs (Application Programming Interfaces) to capture the data automatically. Some of the data had low update frequencies, such as the historical data and the statistical preparation data, which may need a well-organized database for storing and managing.

5.1.3 Findings of Existing Workflow Review

After reviewing the existing workflow of the disaster response, major shortages in the current workflow were found.

5.1.3.1 Long Waiting Time

In the emergency response period, the decision maker needs to review all of the related information and make decisions in a very short time. In the current workflow, after the decision maker queries the data, the query is sent to the disaster response team and then to the external decision support team; the data are subsequently sent from the external team, the response team, and then back to the decision maker. It usually takes over 30 minutes to go through the process, which is an extremely long time for decision making during a disaster.

5.1.3.2 Over-Processing of Data

In the current workflow, all of the data go through the processes of gathering, processing, and confirming, even those data that are already processed by automation techniques. Since no system was developed for integrating all of the data, the data must go through these processes whenever the decision maker queries for the data. The external team and the disaster response team might sometimes need to confirm the data back and forth before sending the data to the decision maker.

5.1.3.3 Unintuitive Internal System

The WRA had developed a system, named the Emergency Disaster Response System, for managing their disaster-related data. The operating procedures were so complicated that the WRA held a training workshop to teach the related personnel to use the system every year. However, the decision makers were usually too busy to attend the workshop, resulting in their inability to operate the system appropriately. Therefore, instead of querying for the data by themselves, the decision makers preferred to ask the internal team to gather the data for them.

5.2 Stage 2: Usability Evaluation

5.2.1 System Prototype

To realize the designed system, a system prototype was developed. The prototype, named Ask Diana, was built on Line, the most common communication App in Taiwan. Ask Diana was designed to have three major modules: disaster-related database, user-intent understanding mechanism, and user interface (Tsai et al., 2019b). Fig. 3 illustrates the prototype of Ask Diana. The prototype

Table 1. Results of the User Need Assessment Interview

Subject's position in the WRA	Data needs for decision support
Deputy minister 1	Weather observation data, statistical preparation data, disaster prevention operation data
Deputy minister 2	Weather observation data, statistical preparation data
Deputy chief engineer	Weather observation data, disaster prevention operation data
Director of the water hazard mitigation center	Weather observation data, historical experience data, international disaster data
Senior engineer	Weather observation data, statistical preparation data, international disaster data

(a) (b) (c)

Fig. 3. Prototype of Ask Diana: (a) The Main Menu of Ask Diana, (b) Example of Retrieving the Weather Related Data by Using Image Map Menu, (c) Example of Retrieving Observed Chart by Using Carousel Menu

Table 2. Designed Test Scenarios

Scenario	Test purpose	Scenario contents
Scenario 1	The user is able to use the basic functions of Line.	Become a Line friend of Ask Diana and say hi to her.
Scenario 2	The user is able to acquire the data by using Ask Diana.	Check the current drought resistance of WRA.
Scenario 3	The user is able to obtain multiple data by using Ask Diana and make judgments.	Make a judgment on whether it is necessary to set up the second-level emergency response center (an upgraded response center in the WRA).
Scenario 4	The user is able to use Ask Diana for their daily tasks.	Look for the predicted rainfall in the next 24 hours.

with the user interface, demo functions, and demo data could be utilized as the usability test platform.

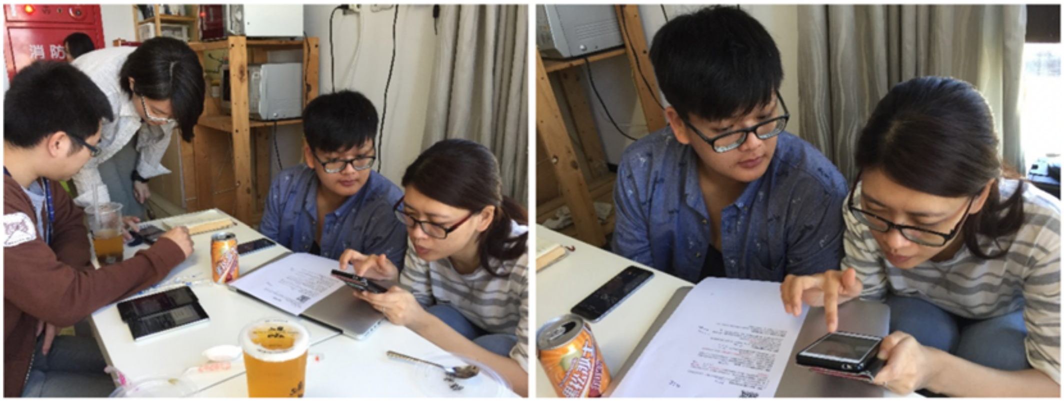
5.2.2 Usability Test

The usability tests were conducted both in the lab and in the field. Four scenarios were designed for testing the functionalities of Ask Diana. During the usability test, the operation details of using Ask Diana, the questions that the user asked, and the time that the user spent to complete the tasks in the scenarios were all recorded by the observer for further analysis.

Table 2 listed the designed scenarios for the usability test. The first scenario was "become a Line friend of Ask Diana and say hi to her." Through this scenario, this research could test if all of the users were able to use the basic function of Line and thus determine if it was appropriate to choose Line as Ask Diana's implementation platform. The second scenario was "check the current drought resistance of WRA." In this scenario, the user was asked to use Ask Diana to look up the reservoir data to know if the water storage was sufficient before the rainy season. The third scenario was "make a judgment on whether it is necessary to set up the second-level emergency response center." In the third scenario, the user was instructed to use Ask Diana to search for multiple types of data, including regulations, real-time rainfall, and the river water level, to make the judgment of whether it was necessary to set up the response center. The last scenario was "look for the predicted rainfall in the next 24 hours." Checking the predicted rainfall is the most common task that the user may need to perform every 10 minutes during a disaster. Therefore, this research designed the scenario to ensure that the process of using Ask Diana to search for the predicted rainfall data was intuitive enough for the user.

The in-lab usability test was held on Nov 29th, 2017. Eight graduate students were involved in the test. All of the participants were familiar with using communication apps, such as LINE and Facebook Messenger. The purpose of the in-lab test was to ensure that the design scenarios were not too difficult for first-time users to conduct. In addition, through the in-lab test, how first-time users would operate Ask Diana and get the data that they need could be assessed (Fig. 4).

The in-field usability test was held on Dec 4th, 2017. This research gathered nine personnel from the disaster response team in the WRA as subjects (Fig. 5). The nice subjects were all in the Disaster Response Group in the WRA and play the roles of data provider and decision supporter. All of them were familiar with



(a) (b)

Fig. 4. In-Lab Usability Test: (a) Questions the User Asked and the Operation Time Were Recorded by the Observer, (b) The First-Time User Operating Ask Diana Based on the Designed Scenarios

Fig. 5. In-Field Usability Test

using communication apps in their daily tasks. However, it was their first time to use chatbot for decision supporting. The subjects were asked to complete the designed scenarios by using Ask Diana. The research team observed and recorded the users' interactions with Ask Diana. The purpose of the in-field usability was to determine if Ask Diana could provide sufficient data and intuitive operating procedures for the real user to conduct their tasks. Furthermore, some of the data, such as predicted rainfall, were controlled; only specific personnel could access those data. Therefore, an additional step in the fourth scenario to let the users apply for special permission to gain accessibility to such data was added.

5.2.3 Results of the Usability Test

During the usability tests, the operating time, behaviors, and the user's questions were all recorded for further analysis. On average, the user took 52 seconds to finish the first scenario, 230 seconds for the second one, 272 seconds for the third one, and 447 seconds for the last one. Six people failed to finish the third scenario. The user behaviors in the usability tests were organized and listed in the following descriptions.

5.2.3.1 1st Scenario

1. The user tried to send stickers to Ask Diana, much like how they would when using the communication app. However, Ask Diana does not handle sticker input.
2. The user used English as the input language, which Ask Diana does not support.
3. When the input queries were out of Ask Diana's scope, Ask

Diana replied, "Sorry, I don't understand what you are asking. Please try other keywords." Some users thought that it would have been better if Ask Diana could reply with different answers to make it seem more like a real person.
4. Some users tried to Ask Diana to analyze the raw data and provide them with the results. However, Ask Diana could only play the roles of data provider and manager, not the analyzer.

5.2.3.2 2nd Scenario

1. Ask Diana could only deal with the preset keywords since it uses a keyword-mapping table as the mechanism to understand user intentions. Some users tried to input the keyword that was not present in the mapping table, resulting in failure to find the related data.
2. A user mentioned that the reservoir data displayed in a table format was difficult to read, especially on a mobile device.
3. The users sometimes queried the data with a long question, which was difficult for Ask Diana to understand; thus, it failed to provide the correct data.
4. When the users wanted to obtain data stored in the cloud drive, such as Dropbox or Google Drive, they needed to install related apps to get access to those data.

5.2.3.3 3rd Scenario

1. Some users tried to type down the question of the third scenario directly, such as "Is it time to set up the second-level response center?" However, as Ask Diana is just a data manager, it could not make judgments for the user.
2. The users mentioned that they had hoped that Ask Diana could analyze existing situations for them so that they only need to make judgments based on the analyzed results.

5.2.3.4 4th Scenario

1. The user could easily find the predicted rainfall data as described in the fourth scenario. However, they spent considerable time in applying for the special permission.
2. The user suggested that the application form for the special permission should be redesigned to be more user-friendly, which could accelerate application efficiency.

5.3 Stage 3: System Improvement

5.3.1 User Feedback Review

Based on the usability test of Ask Diana's prototype, this research found that four major issues should be addressed: data completeness, data revealing, operation process, and decision support information.

5.3.1.1 Data Completeness

During the usability test, the authors found that many users tried to query Ask Diana for data from external resources, for example, the presentation slides from other agencies of the government. However, those data were not built for inclusion in Ask Diana's database.

5.3.1.2 Data Revealing

Most users used Ask Diana on the mobile platform. However, some of the data revealing methods were not designed for mobile devices with small displays. For instance, the original reservoir-related data were displayed in a huge table format, which would make it extremely difficult for the user to browse the data on their mobile phones.

5.3.1.3 Operation Process

Although Ask Diana allowed the users to query for the data by using a button-based interface or inputting keywords, it was still difficult for the users to learn where the node of a specific data was located in the decision tree or what the relevant keywords of the data were.

5.3.1.4 Decision Support Information

The prototype of Ask Diana could only provide polished raw data for the user. However, for further decision support, the user may need some information that is a combination of raw data. For instance, the user may need to know whether the rainfall would reach the preset warning value instead of simply receiving raw rainfall data.

5.3.2 System Improvement Based on Feedback

According to the review results, this research modified or added more functions to Ask Diana to make the system more useful for

Table 3. Comparison of the Original and Improved Decision Trees

Data category	Number of leaves (data)		Number of branches (menu)		Number of total nodes (menu + data)	
	Original	Improved	Original	Improved	Original	Improved
Weather observations	33	37	15	20	48	57
Disaster prevention	10	11	8	9	18	20
Disaster operation	44	60	20	23	64	83
Disaster recovery	10	10	6	13	16	23
Other	45	44	21	44	66	88
Feedback & setting	-	18	-	5	-	23
Total	142	180	70	114	212	294

disaster response personnel. The improved system was officially released at the WRA in Oct 2018 and was renamed "WRA AI robot Diana." The following sections describe how Ask Diana was improved from the perspectives of data completeness, data revealing, system operation process, and decision support information.

5.3.2.1 Adding More Data from External Resources

To increase the completeness of the database of Ask Diana, the authors reviewed the user logs to check the types of data for which the users commonly queried during their daily work or the disaster response period. Table 3 lists the comparison of the decision trees of the prototype and the improved one. After the usability test and user log review, 38 types of data were added to Ask Diana's database, resulting in 82 additional nodes of the decision tree.

In addition to adding more data to Ask Diana, a new category, namely, Feedback & Setting, in which the user can provide feedback to the development team regarding the use of Ask Diana by filling a form was also added. The user can also subscribe to disaster-related warnings for decision support. The detailed explanations about the disaster warnings will be presented in section 7.2.4.

5.3.2.2 Parsing Raw Data through APIs

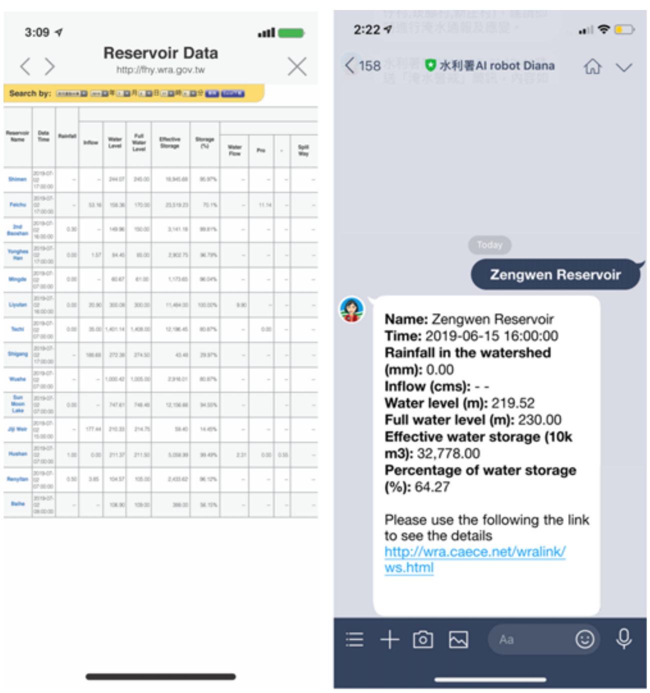
In the prototype of Ask Diana, some of the data were linked with the database through URLs. Therefore, when such data are queried, Ask Diana will provide the user with URLs. However, the revealing method of some of the data was not designed for mobile devices, which caused difficulty for the users in reading the details.

To solve this issue, this research developed several APIs to parse the raw data from the original resources. By doing so, Ask Diana can directly provide specific data rather than the URLs for the user. For instance, Fig. 6(a) illustrates the reservoir-related data that were revealed in a table format. The users might need to zoom in and out and back and forth to check the data that they need. Fig. 6(b) shows that with the parser, the users can query for specific data, such as the water level or water storage.

5.3.2.3 Learning Operation Process Using a Guiding Mechanism

Ask Diana now has 294 nodes in the decision tree, including data and menus. During the usability test, the authors found that such a large-scale structure would make it difficult for the users to memorize all of the relevant keywords of data in the system. The user would spend more time on browsing the data through the designed menus rather than on typing the keywords directly.

Therefore, this research developed a guiding mechanism to help the user operate Ask Diana (Fig. 7). With the guiding mechanism, Ask Diana would send a keyword-reminding message, starting with "I need," when the user uses the menu buttons to browse the data. The users can thus become familiar with the relevant keywords of their commonly used data



(a) (b)

Fig. 6. Parsing Raw Data through APIs to Solve the Data Revealing Issue on Mobile Devices: (a) Reservoir-Related Data Revealed in a Table Format, (b) Revealing the Reservoir-Related Data Directly with Text Messages

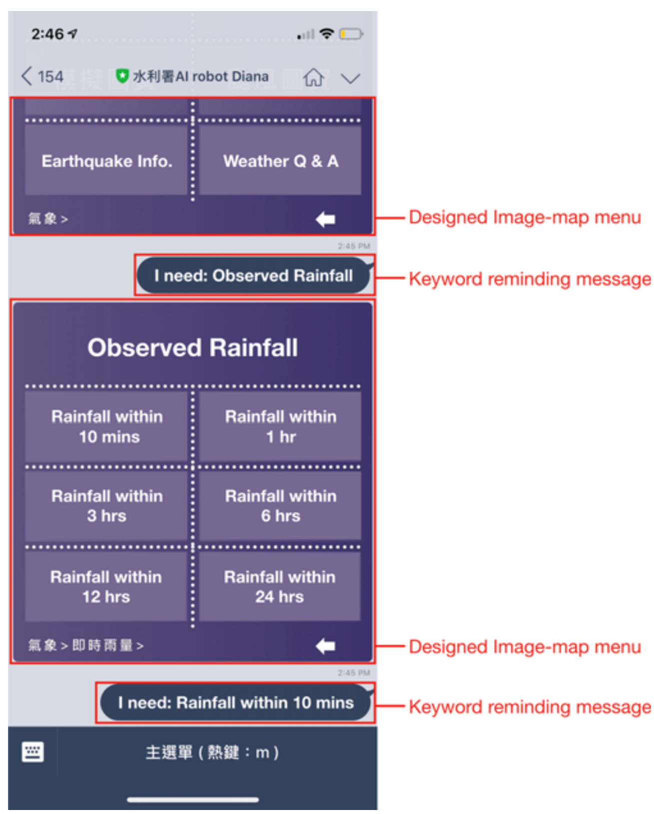


Fig. 7. Guiding Mechanism of Ask Diana

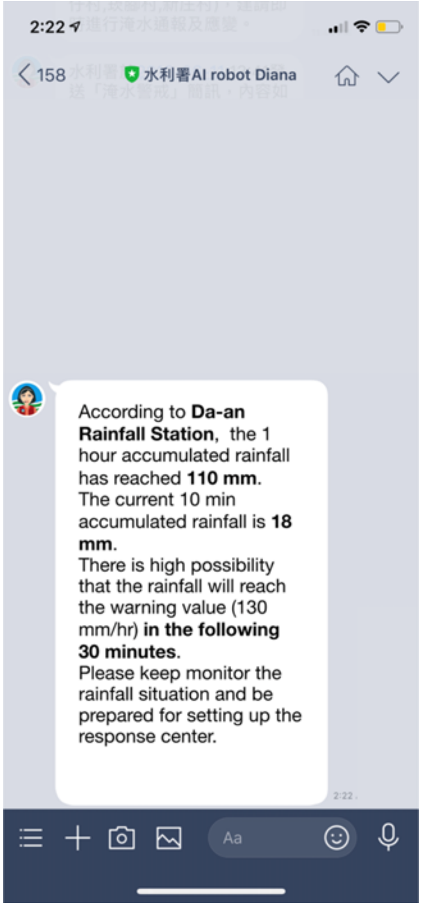


Fig. 8. Instant Warning Message for Decision Support

gradually without investing additional time on memorizing the keywords.

5.3.2.4 Sending Push Notifications of Instant Warning Messages for Decision Support

Besides being reliant on disaster-related data or information, making decisions highly relies on the decision maker's experience and judgment as well. Therefore, it is hard for Ask Diana, as a data management system, to answer questions such as "Should I setup the response center now?" or "Should I evacuate the people from the mountain area?" However, Ask Diana can effectively play the role of a decision support manager.

In this improvement, a beta function of providing push notifications of instant warning messages for decision support was added. Ask Diana can now compare the raw data with the regulations and generate a warning message for the decision maker. Being a chatbot on the messenger platform, Ask Diana is able to push the generated warning messages to the decision makers as a reminder for them of the current situations (Fig. 8).

5.4 Stage 4: Management Plan

5.4.1 New Workflow with the Chatbot System

Figure 9 illustrates the newly developed workflow of decision making in the WRA. With the implementation of the chatbot system, Ask Diana, the decision support team can access the raw data by using Ask Diana and send the processed data back to its database. Not only the disaster response team but also the decision makers can directly query for all of the data through

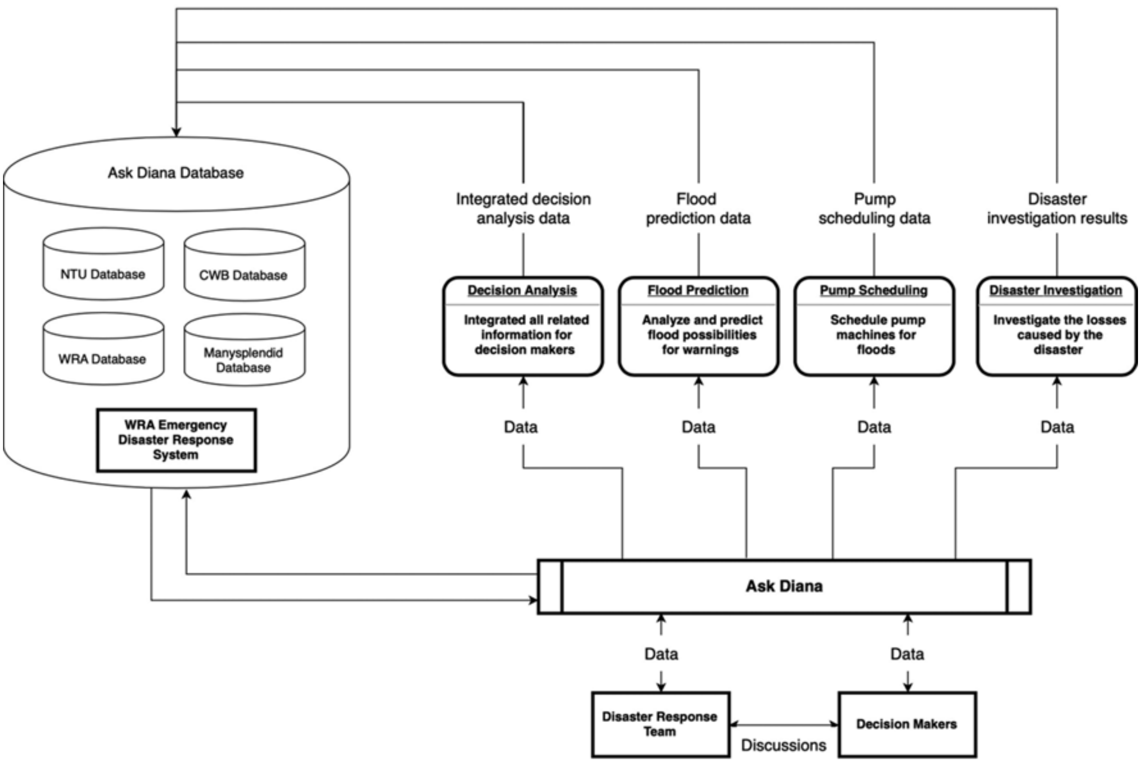


Fig. 9. New Workflow after Implementing the Chatbot in the WRA

Ask Diana without repeatedly inquiring the decision support teams. Additionally, as Ask Diana is built on a commercialized messenger app, the decision makers and disaster response team can communicate and discuss with each other to make an appropriate decision by forwarding the data obtained from Ask Diana. With this workflow, the issue of long waiting time can be solved because the related personnel do not need to communicate back and forth to ask each other for the data. They only need to Ask Diana, which will give the data to them instantly without any waiting time. In addition, since all of the data are gathered in Ask Diana's database, the decision support team can easily retrieve the data that they need and send the processed data back to the database. Lastly, because the chatbot is on a commercialized app, the learning curve of the operating system is significantly reduced. This implies that the WRA will not need to hold an annual training program for related personnel.

5.4.2 User Interview to Develop the System Improvement Plan

The authors interviewed the decision makers and the disaster response team to understand their use of the chatbot system in the real field. Then, the authors planned the system management standard according to the users' feedback.

After implementing the improved chatbot system for eight months, the authors interviewed the decision makers and the disaster team. To receive feedback from users, this research designed a questionnaire with three questions: 1) What kinds of data would you like Ask Diana to help you with during the "disaster prevention" period?; 2) What kinds of data would you like Ask Diana to help you with during the "disaster response operation" period?; 3) What functions would you like Ask Diana to offer to assist in your disaster prevention tasks?

The interview was held on June 12^{th}, 2019 when a flood disaster hit Taiwan. Fifteen disaster response personnel were interviewed. The user feedback can be categorized into three major issues.

5.4.2.1 More Data

Ask Diana should include more types of data for the user's daily tasks. The included data should be related to not only the decision maker but also personnel at other levels.

5.4.2.2 More Information

Ask Diana should be able to post-process the raw data and convert the data into useful information for decision support; for instance, Ask Diana could integrate the rainfall and disaster situations for the pump distribution tasks.

5.4.2.3 More Accuracy

Ask Diana should set up a data updating plan, including the data type, the updating frequency, and the responsible personnel or agency. Since Diana is utilized in a government department, it is important to confirm the accuracy of every data to ensure system reliability.

5.4.3 Management Plans

The management plan contains three major parts: the data updating plan, regular review of user logs, and system improvement plan.

5.4.3.1 Data Updating Plan

For the data updating plan, this research listed all of the data to discuss the updating frequency with the related personnel, especially in relation to the static data. The development team needs to follow the plan to update the data in Ask Diana's database so that Ask Diana can provide accurate and instant data for the user.

5.4.3.2 Regular Review Plan

The development team needs to review the user logs regularly to observe the user behaviors. By reviewing the user logs, the developing team can know what types of data are frequently used or what else the user needs to obtain from Ask Diana.

5.4.3.3 System Improvement Plan

A continuous improvement plan usually plays an important role in maintaining a data management system. The development team needs to be continuously aware of the user needs and set the system improvement according to the user needs. In this research, the users in the WRA indicated that they would like Ask Diana to have the function of customizing the data based on the user's duties. In addition, Ask Diana should be able to analyze more data for further decision support, for instance, whether the user needs to set up the response center. Moreover, the users hoped that Diana could integrate more data from other departments so that they can discuss the data with those from other departments when compounded disasters are encountered.

6. Discussions

The contributions of this research are as follows: 1) Knowing the potential and limitations of a chatbot system for data management; 2) Gaining practical experience of implementing a chatbot system in a data management system (it is recognized that implementation of such a system is difficult for government agencies); 3) Providing a systematical approach to solve the problem.

This research proposed the EUSM framework for the implementation of the chatbot system for disaster-related data management. Through the design and a real case study, the three major contributions of this research have been concluded:

6.1 Knowing the Potential and Limitations of a Chatbot System for Data Management

In a decision support system, usually a huge amount and large varieties of related data are involved, especially for a government department. Knowing the potential and limitations of a chatbot system in the early development stage allows the developers to determine the role of the chatbot and thus the number of types of data that should be contained in the system.

6.2 Gaining Practical Experience of Implementing a Chatbot System

Developing a system for decision makers, especially for the government, is always difficult since the decisions that they handle may greatly influence the residents. This is also why the government rarely adopts new technology. The authors of this research cooperated closely with the decision makers and their supporting team to know their actual needs, solve their real problems, and implement the new system in their daily work.

6.3 Providing a Systematical Approach Using a Case Study to Solve the Problem

This research proposed a four-stage framework for implementing a chatbot system as the data management tool. In this research, a newly developed chatbot system was utilized step by step in a real field; to illustrate how the framework can help users implement such a system, a demo case was presented by interviewing users, prototyping the system, testing the prototype, improving the system, and preparing the management plan.

7. Conclusions

This research proposed a four-stage framework for implementing a chatbot as the data management system. The proposed framework aims to help the disaster response department, especially in the government, to reduce the threshold of incorporating new technology into their existing work procedures. The developed four stages are existing workflow review, usability evaluation, system improvement, and management plan. The department or agency, who would like to utilize a chatbot system, can follow the proposed framework to design, implement, and maintain the chatbot for their working processes. A case study was also conducted for validating the effectiveness of the developed framework. In the case study, a decision support chatbot for Taiwan's government department, which was developed by the authors in previous studies, was utilized. By conducting the four-stage framework, the chatbot system is now integrated into the government's daily working processes. It represents that the developed framework is able to help the government with introducing a new technology for data management. In the future, the EUSM framework can be utilized in any other types of chatbot development, such as for earthquake disaster management, construction management, construction site security systems, or other fields.

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